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Some Observations on the Growth of Captive Alligators

(Figures 1-2)

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Alligators collected in Louisiana coastal regions immediately after hatching were kept in outdoor concrete tanks at about 30°C for periods as long as two years. They were fed ground marine fish on five or more days of each week in all seasons of the year. They grew rapidly reaching lengths of three feet in one year and almost five feet in two years, and they outweighed severalfold wild alligators of the same age. Their mortality rate was only a fraction of that estimated for comparable wild alligators. It appears that use of "brooders" is a practical (and inexpensive) means of restocking depleted areas.

INTRODUCTION

A CONTINUING DEMAND for hides and increased drainage for land reclamation threatens many species of crocodilia with extinction. Where conservation is practiced, it involves prohibiting killing animals of any size, or of those below a certain body length. The results of these measures have not been encouraging, as sufficient funds have rarely been made available to provide enough men to police the waterways and swamps, terrain that provides concealment for the poacher.

Although attempts to increase the population by establishing breeding colonies have not been very successful in the past, encouraging results have been obtained recently (Youngprapakorn, Cronin, and McNeely, 1971) and it is to be hoped that such methods will eventually permit restocking areas depleted by hunters and hide collectors. In the interim, a system whereby newly-hatched crocodilians are taken from the nest and raised in compounds for future release may offer promise for immediate relief. Crocodilians, almost helpless at birth, have few natural enemies when they have reached a body length of three feet or more (McIlhenny, 1935).

The following account records some of the observations derived from several years of experience on the growing of young alligators in captivity.

MATERIALS AND METHODS

Over a period of several years some 600 alligators were obtained from the Louisiana Wildlife and Fisheries refuge at Grand Cheniere, Louisiana, through the cooperation of Ted Joannen and Allan Ensminger. Those used in the first year growth experiments were first fed on September 15. At the conclusion of the growth studies, all were returned to the swamps by agents of Wildlife and Fisheries.

Alligator Tanks

The outdoor tanks for housing the newly hatched animals were about 1.5 meters long by 0.6 meter deep by 0.75 meter wide, with a 5 cm drain placed at each end at the bottom of a gentle slope. They were of smoothed concrete about 5 cm thick covered with a "press-metal" diamond shaped mesh of about 2.5 cm holes. In winter the tops were covered with ultra-violet transmitting thin polyethylene sheets which also reduced evaporation and conserved heat. Although all tanks were ex-

posed to direct sunlight in the winter, a tall stand of banana "trees" shaded them from the late afternoon sun in the summer. Each tank was equipped with a 500 watt immersion heater and the amount of heat delivered was controlled by a heavy-duty "power-stat" from inside the laboratory. The total heating capacity at its maximum was sufficient to maintain a 25 cm water depth at 30°C, except in very cold weather (below 5°C) when water temperatures as low as 23°C were recorded. Although this was not entirely satisfactory, inadequate heating at the New Orleans site (Pitcher Plaza, Louisiana State University Medical Center) was experienced at scattered periods for no more than 20 days in the year.

Water was changed about three times a week. Those tanks housing alligators under one year of age were provided with a two-foot square plywood platform for basking, which cleared the surface by less than two cm. Food was placed on the platforms and it was necessary for the animals to leave the water to feed. Larger alligators (up to 150 cm), which were not provided with areas for basking, did not appear to suffer from being forced to remain in the water for months at a time.

Food

The diet consisted solely of marine fish, fed whole to the large alligators, and ground coarsely (bones, scales, and all) for the smaller ones. The fish were obtained from a local wholesale fish dealer (Louis Cognevitch) and the following is roughly the ratio of the contributions of the various species fed: southern kingfish (*Menticirrhus americanus*), 55 percent; Atlantic croaker (*Micropogon undulatus*), 15 percent; spotted seatrout (*Cynoscion nebulosus*), 10 percent; and from 1 to 4 percent of striped mullet (*Mugil cephalus*), red snapper (*Lutianus campechanus*), and black drum (*Pogonias cromis*). The remainder represented at least a score of other species. Since the fish were marine in origin, they probably contained significant amounts of vitamin D, although the availability of ultraviolet from sunlight may well have rendered dietary vitamin D unnecessary. For the small alligators (during the first year after hatching), food was supplied *ad lib.* For those beyond one year of age, feedings were restricted in the winter to two or three times a week. No vitamin supplements were given.

The total quantity of fish consumed was estimated by weighing the fish placed in the tank, followed by weighing the amount remaining in the tank the next day. The uneaten portion was then removed, and once again an excess of weighed fresh fish was added, etc.

Results

Relationship Between Length and Body Weight

Total body length measurements and weights may be determined with ease on alligators that are below 180 cm in length. Beyond that size lengths may be measured easily, but body weights are difficult to determine and most of those reported are suspect. Length-weight relationships on several species of crocodilia were reported by Dowling Brazaitis (1966), but the actual number of individuals measured seems to have been small. In view of the paucity of knowledge, several hundred alligators of various sizes were weighed and the total body lengths were determined. All of these animals had been kept in the outdoor tanks and pens for some time, and they had been well fed for considerable periods. Although heavier than wild alligators taken from the South Louisiana marshes, they did not appear grossly corpulent. The relationship between total length and body weight of some of these captive alligators is shown in Figure 1. Specimens below 120 cm in length were so numerous that the points ran together and many were therefore omitted.

The observed slope of the curve corresponded to the points marked with an X. The relationship may be expressed in the form of a straight line by plotting the $\log_{10}$ of the weight in kg against the $\log_{10}$ of the total length in cm. J. D. Herbert (personal communication, 1971) derived a formula which seems to apply to all alligators from those newly hatched to those several meters long. $Y = ax + b$ (the equation for a straight line) appears to apply if $y = \log_{10}$ of the weight in kg, $a = 3.35$, $x = \log_{10}$ of the length in cm, and $b = -6.10$. Not enough information is available to verify the equation for alligators beyond three meters length, but a few reports of length-weight measurements on specimens beyond three meters (Dowling and Brazaitis, 1966) suggest that the formula may apply to all sizes. If it does apply, a well nourished six-foot (183 cm) alligator would weigh 30 kg, a seven-footer (213 cm) 50 kg, an eight-footer (244 cm) 79 kg, a nine-footer (274 cm) 117 kg, a ten-footer (304 cm) 168 kg, an eleven-footer (335 cm) 229 kg, etc.

The Factor of Temperature

Although alligators inhabit a region which is largely sub-tropical, it appears they need very high temperatures for satisfactory growth and physiological function (Brattstrom, 1965). If they were exposed to the comparatively mild temperatures of 18°C (65°F) some impairment of renal function occurred (Coulson and Hernandez, 1964). A normal alligator excretes massive amounts of NH_4HCO_3 which serves two functions, salt retention and nitrogen excretion. At temperatures below 18°C, the ability to synthesize NH_4HCO_3 was reduced and as a consequence, NaCl was lost to the urine (Hernandez and Coulson, 1957). In addition to the renal effects, desire for food was diminished or absent at temperatures below 22°C regardless of the season. From the results of a prolonged series of experiments, it appeared that temperatures between 29°C and 31°C were best for

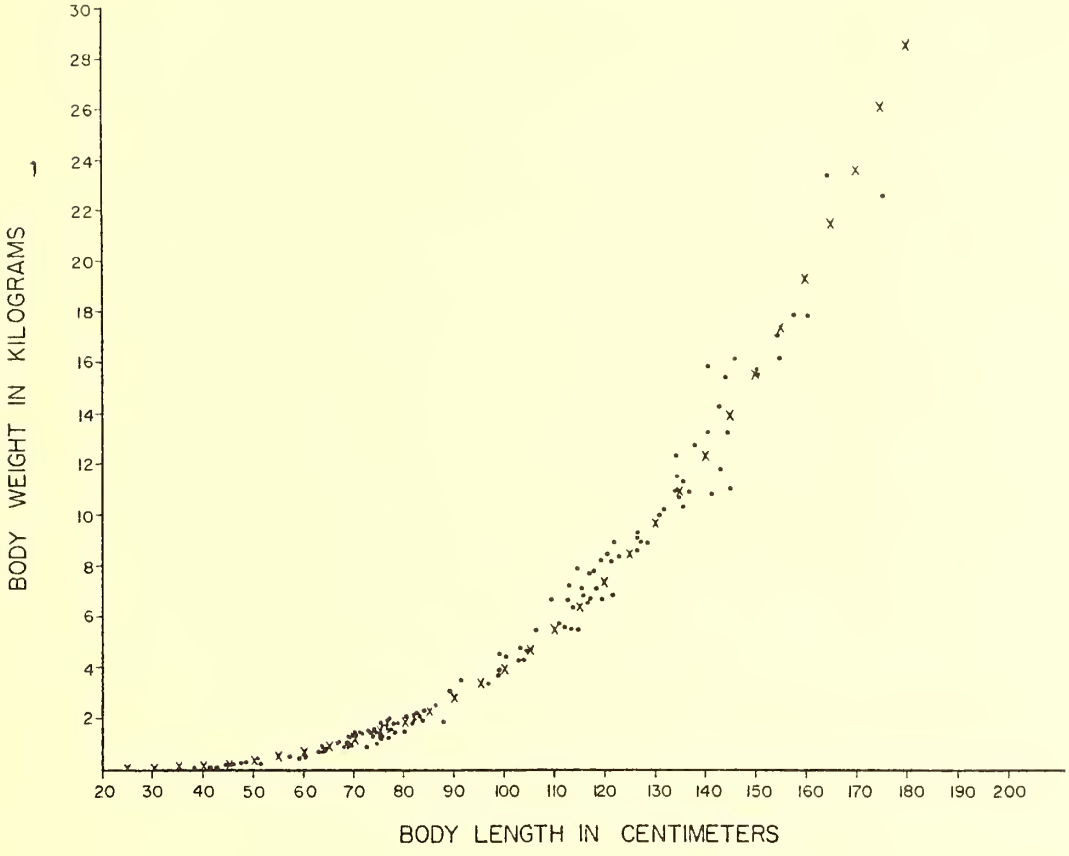

FIGURE 1. Relationship between total length and body weight in alligators up to 180 cm in length. Each dot represents a single specimen. The X's represent the apparent average. J. Herbert (personal communication, 1971) derived a convenient expression from the data which appears to be useful for all alligators from the smallest to the largest. The formula $y = ax + b$, the equation for a straight line, applies if $y = \log_{10}$ of the weight in kilograms, $a = 3.35$, $x = \log_{10}$ of the length in centimeters, and $b = -6.10$. Although reliable data on wild specimens is scarce, it is probable that the somewhat thinner wild alligators would conform to a weight-length curve shifted to the right of the one above.

the alligator even in winter. High temperatures also facilitated the absorption of the yolk sac, a factor that appeared responsible for reducing the reported high mortality rate (Joannen, personal communication, 1971) to below 10 percent. Those kept at cooler temperatures retained the yolk sac for months, and a high percentage developed an abdominal tumor of sufficient size to prevent food from entering the stomach.

Growth Rates

The growth rates of alligators in these experiments (Figure 2) were far greater than those reported for wild alligators (McIlhenny, 1935). The curve was drawn from the median weights and lengths of about 200 small alligators for the first year and from about 25 for the second year. Some 10 percent of each group of new-hatched alligators that were received failed to grow appreciably.

In all visible respects, the year-old alligators were in excellent health, their skins were unmarred, their teeth were straight, and they resembled wild alligators twice their age, except for the fact that the captive animals were heavier. The two-year-old captive alligators were as long as local wild alligators at four-and-one-half years (McIlhenny, 1935) and about 10 percent heavier for their length.

Food Consumption

The food consumed was determined for scores of alligators of various ages and weights over a period of several years. The smallest alligators converted over 40 percent of the weight of the food eaten into body mass, and those alligators from one year to three years of age converted about 25 percent. The average cost for an alligator for the first year after hatching was about 55 cents, and for the second year, about $3.50 (calculated on the basis of five cents a pound for fish).

Protrusion of the Cloaca

Large alligators (over five feet in length) that were being fed at a maximal rate occasionally developed a disorder of the cloaca in which the entire region protruded ventrally by as much as two inches. The disorder appeared to be the result of pressure in the abdominal area caused by chronic engorgement or by deposition of fat around the cloaca. Abrasion of the lesion led to bleeding when the animals were on dry concrete a good part of the day, but if they were fasted and forced to remain in water, the condition improved in a few days and no permanent damage resulted.

Parasites

Most large alligators caught in the wild suffer from intestinal parasites, usually round worms. Infected animals were usually very lean and some refused food for months. This problem was not serious in the captive animals and the parasites disappeared within a few months, if the absence of round worms in the fecal matter was an indication. Although no study was made of the types of parasites in the wild specimens or of their incidence in the captive animal's intestines, it was our impression that parasitism did not limit growth under the conditions reported here. No attempts were made to treat the infected animals with antihelminth drugs.

Imported caimans (*Caiman crocodilus crocodilus*) are infested with worms, and the mortality rate of the small ones is very high even when kept under the same conditions as the small alligators. The possibility that imported caimans could infect the alligators was a problem of concern; however, there was no evidence that this occurred.

Gout

This classical disease of man had been reported in "alligator, species unknown," (Appleby and Siller, 1960), but the article did not state whether the animal was captive or wild. In the early years of the growth studies, this disorder occasionally proved a problem in the well-fed captive alligators. If an alligator is in a period of rapid growth, most of the nitrogen ingested is converted quickly into body protein and the amount excreted is not beyond the capacity of the kidneys. On the other hand, if an alligator is accustomed to daily feedings, it is possible for it to ingest protein and digest it faster than it can remove the amino acids by the route of protein synthesis. The unused amino acids pass their nitrogen to ammonia formed in the kidney and to uric acid synthesized in the liver (Coulson and Hernandez, 1964). When they were "overfed" for a long period, uric acid was deposited in the joints, over the sternum, and eventually in the soft tissues in massive amounts. Paralysis occurred first in the front legs and later in the back legs, and death resulted apparently from damage to the kidneys which were packed with urates. The problem was most severe in winter, at a time when the growth rate was the lowest. If the alligators were fasted for a week or so after the appearance of the first signs of paralysis, all recovered quickly and the regular feedings were resumed. Fortunately, alligators under a year of age were not as prone to develop the disease and food restriction was seldom necessary. When the nature of the problem was understood, no further deaths occurred from gout. Aside from a few "infant mortality" deaths in the first few weeks after hatching, there have been no deaths from any cause in an average population of 100 alligators in the past three years.

Discussion

Alligators are carnivorous. In their natural habitat, small ones eat insects, crayfish, small fish, frogs, etc., and large ones eat fish, rodents, and other small mammals, snakes, turtles, birds, insects, and assorted crustaceans. Since turtles are an important item of the diet, it is evident that alligators are accustomed and prepared to handle

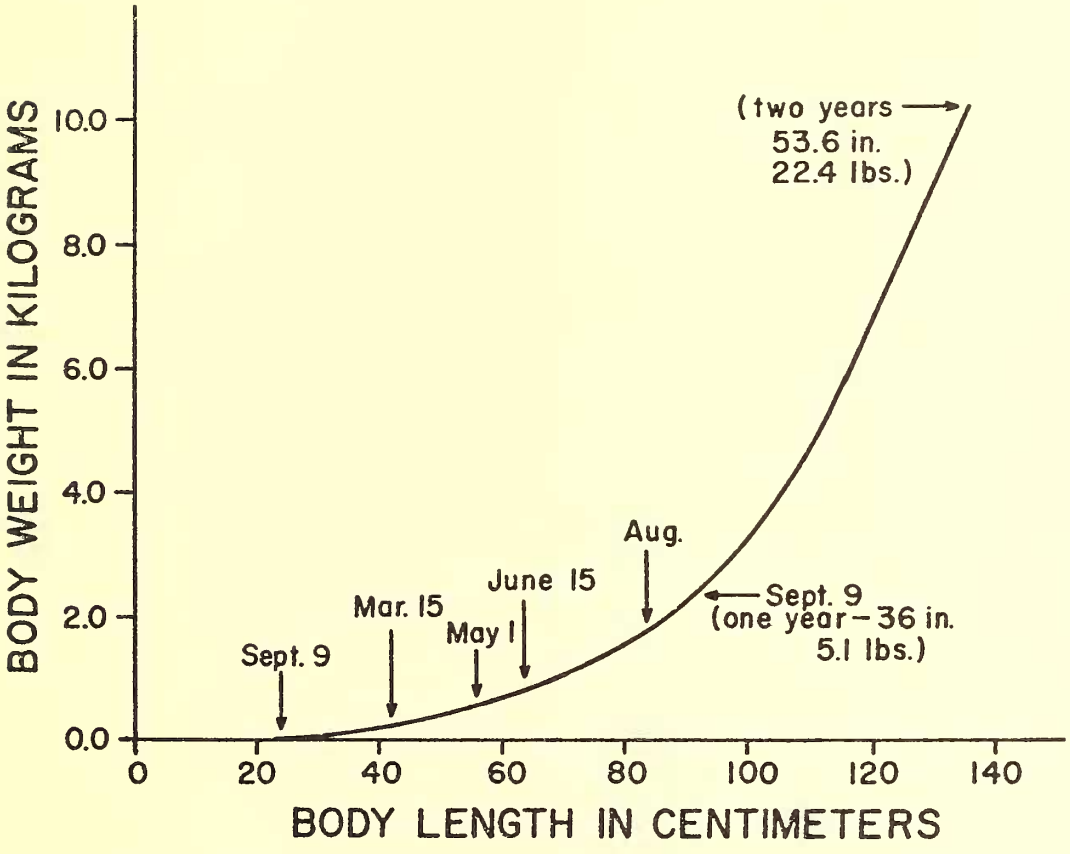

FIGURE 2. Weights and total body lengths of captive small alligators over a two-year period. The data for the first year were derived from the median weights and lengths of about 200 alligators, and that for the second year from 25 alligators. The median weights of the two-year-old captive alligators were about 14 times that of wild specimens of the same age (McIlhenny, 1935).

large amounts of bone. The problem of digestion is apparent if one considers the nature of the shell of the common slider turtle (*Chrysemys scripta*), one of the favorite foods (personal observation). In defense against the mechanical problems involved, the stomach is a powerful organ, and the lumen is supplied with more hydrochloric acid than is found in any other known animal (Coulson, Hernandez and Dessauer, 1950). Almost all of the calcium and phosphate of the bone is excreted by way of the gut, and when alligators receive a natural diet, the feces are almost entirely calcium phosphates and carbonates (Coulson and Hernandez, 1964). It would be logical to assume that in any captive colony large amounts of bone should be supplied in the food. Deficiencies of calcium phosphate and vitamin D in the diets of alligators kept in the laboratory or as household pets often lead to the development of severe rickets characterized by misshapen limbs and a curious shortening of the head (personal observation).

The cost and availability of chicken necks has led to their widespread use for alligator food by roadside exhibitors. This may not be in the best interest of the alligators, since most chickens produced commercially have received the synthetic female sex hormone, stilbesterol. The possibility of hormonal sterilization should be considered.

The Rate of Growth

It is of course not possible to state what the rate of growth would be under "ideal" conditions. Alligators in the wild grow at rates determined by such factors as the temperature of the water and of the air, the hours of sunshine, and the amount and type of food available. It has been stated that small wild alligators grow about a foot a year for five years and somewhat more slowly thereafter (McIlhenny, 1935). Those taken from the wildlife refuges in coastal Louisiana grow little from the time of hatching to spring, picking up rapidly in June, and tapering off again in October. From November to April, they are said to be "hibernating," although in the true sense they do not hibernate as their metabolic rate is the same in winter and summer if the temperature is constant (Hernandez and Coulson, 1952). However, growth and the natural appetite associated with it is not dependent entirely on temperature, and alligators will not grow as fast in winter as in summer (Figure 2) at the latitude of New Orleans (30° N). It would be of interest to follow the growth rates of alligators kept in equatorial latitudes, and at least one such experiment is under way (T. Joannen and A. Ensminger, 1971, personal communication).

Fortunately, our alligators were able to stand considerable crowding without apparent adverse effects on growth rates, a factor of importance when the cost of housing facilities is considered. An area of 600 square feet, half with water and half dry, is sufficient to house and feed about 5,000 alligators from the time of hatching to one year of age. In the second year, at least ten times as much space would be needed for the same number of animals.

Unanswered Questions

The fact that one can grow alligators in captivity at a great rate does not mean that one can necessarily reduce the time required for the development of breeding stock. Wild egg-laying females are beyond five or six feet in length, but we do not know whether they must also be over five or six years old. If size is the sole determinant of breeding capacity, three-year-old captive alligators would be more than large enough; if age is the determinant, domestic females would be full-grown by the time they can breed.

Of the hundreds of alligators housed at the Louisiana State University unit over the years, males have exceeded females by better than three to one. Others have commented on this phenomenon as it seems to be true for crocodilians generally.

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